MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 2, 2017/2018**

## EMG4096 – RADAR SYSTEMS DESIGN AND ANALYSIS

( TE )

9 MARCH 2018
9:00 a.m – 11:00 a.m
( 2 Hours )

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**INSTRUCTIONS TO STUDENTS**

1. This Question paper consists of 6 pages with 4 Questions only .
2. The student is required to answer all questions in the this question paper. Each question carries a particular marks and the distribution of the marks is given .
3. Please write all your answers in the Answer Booklet provided .

Question 1

(a) With aid of a diagram, discuss the basic operation of the radar system. The diagram must consist of the basic module of radar system.

[8 marks]

(b) A radar requires a minimum received power of $10^{-12}$ watts in order to achieve a desired detection performance when observing a (non fluctuating) target with an RCS of 5 square meters. This case corresponds to a minimum single pulse signal to noise ratios of 12 dB. The radar operates at 1.26 GHz operating frequency, has a 3 dB noise figure, and uses a parabolic reflector antenna having an aperture efficiency of 0.55 and a diameter of 6 m.
[Boltzmann's constant ($1.38 \times 10^{-23}$ J/K)]

(i) Calculate the real aperture of the antenna and effective aperture of the antenna.

[4 marks]

(ii) Estimate the gain of the radar's antenna from (i) in dB.

[3 marks]

(iii) Calculate the required minimum peak transmit power if the target is located at a range of 25 km.

[3 marks]

(iv) Calculate the smallest range resolution that the radar can achieve with the configuration above.

[4 marks]

(v) Calculate the desired Pulse Repetition Frequency (PRF) to ensure a target at range 25 km away can be measured unambiguously.

[3 marks]

**Continued .....**

Question 2

a) Figure Q2 shows a FM-CW radar signal with triangular frequency modulation.

(i) A target is located at 250 m from radar system, calculated the intermediate frequency ($f_{IF}$) measured by the radar.

[5 marks]

(ii) If the target is an aircraft moving towards radar with velocity of 100 m/s, compute $f_{IF,UP}$ and $f_{IF,DOWN}$.
Sketch the instantaneous RF frequency for the above target.

[10 marks]

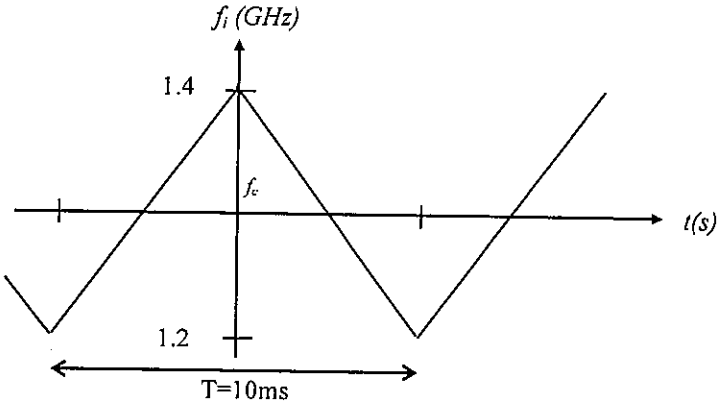


Figure Q2: Instantaneous frequency of transmitted waveform

(b) A receiver receives $6\times10^{-11}$ Watts of signal power, has a bandwidth of 500 MHz, and operates in a 290 K external noise environment. Under these conditions, the signal to noise ratio (SNR) at the output of the receiver is 10 dB. Calculate the Noise Figure (NF) of the receiver. [Boltzmann's constant ($1.38\text{x}10^{-23}$J/K)]

[4 marks]

(c) Define the term **radar clutter**. Briefly describe **surface clutter** and **volume clutter**.

[6 marks]

**Continued .....**

Question 3

a) With aid of a diagram, briefly discuss the monopulse technique used in tracking radar.
State Two (2) reasons why monopulse method dominates modern radar tracking system.

[9 marks]

(b) Briefly describe the **Central Limit Theorem** in radar analysis and the importance of it.

[5 marks]

(c) Explain the following terms with appropriate equation:
(i) Probability of false alarm.
(ii) Probability of detection.

[8 marks]

(d) Figure Q3 shows the probability of detection versus single pulse SNR for several values of $P_{fa}$ (probability of false alarm). Based on the plots, determine the required SNR to obtain the following coherent detection probabilities,
(i) $P_d = 90\%,\ P_{fa} = 10^{-12}$
(ii) $P_d = 80\%,\ P_{fa} = 10^{-10}$
(iii) $P_d = 70\%,\ P_{fa} = 10^{-8}$

[3 marks]

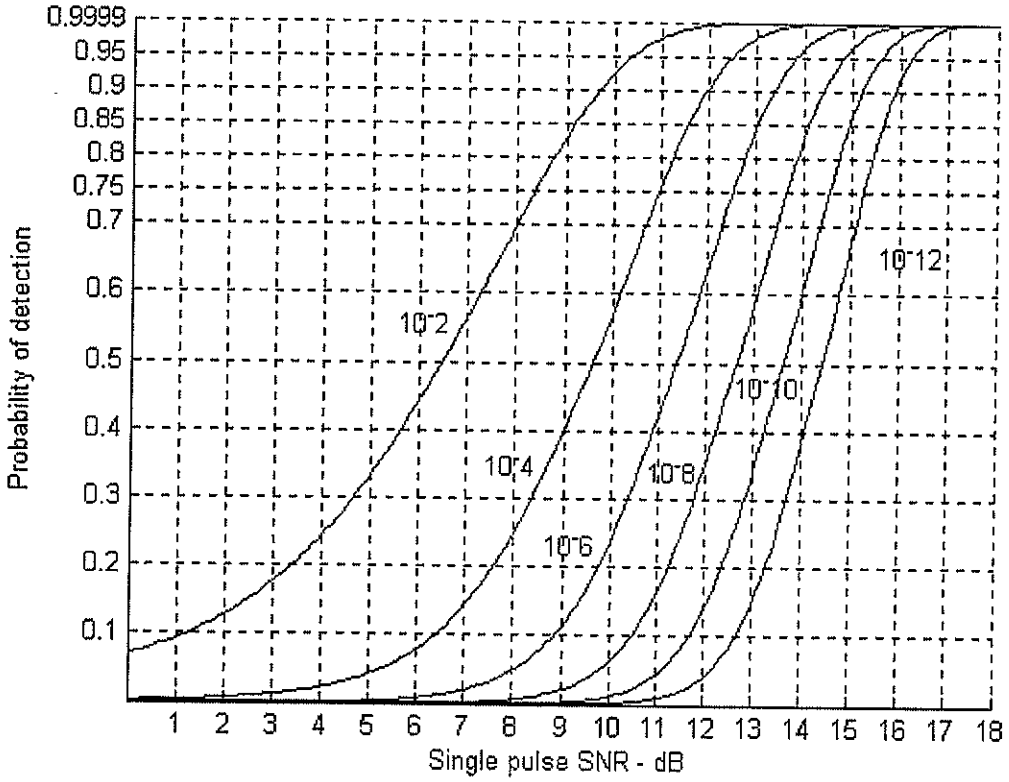


Figure Q3: Probability of detection versus single pulse SNR for several values of $P_{fa}$

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Question 4

(a) A radar operating at 9 GHz uses two PRFs with stagger ratio 9/10. If the first PRF is 1000 Hz, compute the first blind speed for both PRFs and for the resultant composite PRF.

[7 marks]

(b) Fig. Q4 shows the block diagram of an airborne synthetic aperture radar (SAR) system.

(i) What is the main purpose of using dual antenna system in this design?

[3 marks]

(ii) What is the main disadvantage if we replace the dual antenna system in the figure to a single antenna system with circulator?

[3 marks]

(iii) What is the main objective of Low Noise Amplifier (LNA) in the receiver?

[2 marks]

(iv) What is the main function of the 100 MHz oscillator in this design?

[2 marks]

(v) A 500 MHz A/D is used to sample the return echo. What is the maximum allowable bandwidth for the based-band/Intermediate Frequency (IF) signal in this design?

[3 marks]

(vi) Calculate the range resolution of the SAR system in Fig. Q4.

[2 marks]

(vii) If the azimuth resolution requirement is 1 m, suggest a suitable length of the antenna to be deployed in this SAR system.

[3 marks]

**Continued .....**

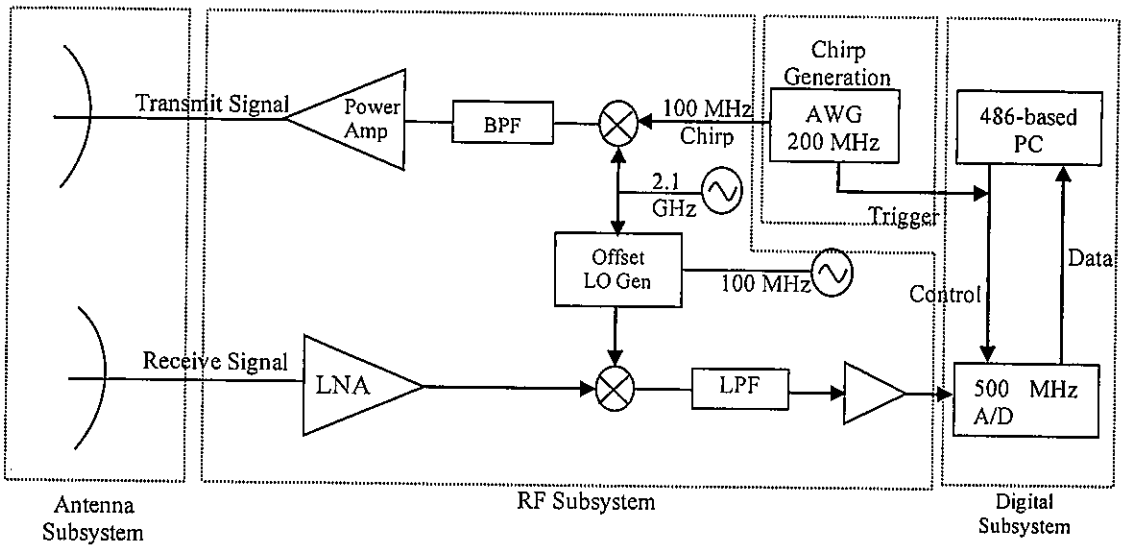


Figure Q4: Block Diagram of an Airborne SAR System

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